OPTICAL COMPENSATION SHEET AND LIQUID CRYSTAL DISPLAY

FIELD OF THE INVENTION

The present invention relates to an optically compensation sheet and a liquid crystal display.

BACKGROUND OF THE INVENTION

The following three constitutions as described below have been proposed as an optically compensation sheet for obtaining a wide viewing angle of a liquid crystal display.

(1) a method providing a discotic liquid crystal compound, which is a negative uniaxial compound, on a support

(2) a method providing on a support a nematic polymeric liquid crystal compound with a positive optical anisotropy, which is subjected to hybrid orientation in which the pretilt angle of the liquid crystal molecules varies in the thickness direction

(3) a method providing on a support two layers containing a nematic liquid crystal compound with a positive optical anisotropy, in which the orientation direction of the layers crosses each other at approximately 90 degrees, so that an optical property approximate to a negative uniaxial optical property is obtained

However, the above constitutions have the following problems.

Method (1) shows a defect specific to a discotic liquid crystal compound in that, in a TN mode liquid crystal display panel employing the discotic liquid crystal compound, the displayed image appears yellowish, when viewing the panel obliquely.

In the method (1) a temperature developing a liquid crystal is high and orientation cannot be fixed on an isotropic transparent support such as TAC (cellulose triacetate), and requires additional processing, in which a liquid crystal compound is oriented and fixed on a first support, and transferred onto a second support such as TAC. This processing is more complex, resulting in lowering of productivity.

There is disclosed in, for example, Japanese Patent O.P.I. Publication No. 8-15681, one example of an optically anisotropic layer employing a positive uniaxial low

molecular weight liquid crystal compound according to method (3). The example is an optically anisotropic layer comprised of four layers which consist of a first oriented layer having an orientation ability, a rod-shaped, positive uniaxial low molecular weight liquid crystal compound layer, in which the liquid crystal compound is oriented and fixed, provided on the first oriented layer, a second oriented layer having an orientation ability provided on the rod-shaped, positive uniaxial low molecular weight liquid crystal compound layer, and a rod-shaped, positive uniaxial low molecular weight liquid crystal compound layer, in which the liquid crystal compound is oriented and fixed, provided on the second oriented layer. In this example, a property approximate to a disc-shaped compound can be obtained, for example, by arranging the two rod-shaped, liquid crystal compound layers so that the orientation directions in the plane of the two layers cross each other at 90 degrees.

Accordingly, method (3) above is extremely advantageous in usage in a liquid crystal TV (television) giving priority to color reproduction, since there is no problem of yellowing occurring in the use of a discotic liquid crystal compound.

Although the use of the discotic liquid crystal compound requires only one layer, however, method (3) requires two

liquid crystal compound layers, resulting in lowering of efficiency.

However, the above three methods have, in common, a fundamental problem. That is, in order to obtain optical compensation ability, these methods require an optical compensation sheet to be provided on both sides of, for example, a liquid crystal cell. This means that even the method for employing an optical compensation sheet, which is convenient for improving viewing angle, results in a cost increase. In these methods, the use of one optical compensation sheet destroys symmetry, and results in asymmetry of the viewing angle. For example, when the optical compensation sheet, the rubbing axis of which is rotated 45 degrees, is arranged, symmetry may be improved but the viewing angle property is not improved. There have been no proposals in which the use of only one optical compensation sheet improves the viewing angle property to the same degree as or more than two optical compensation sheets.

SUMMARY OF THE INVENTION

An object of the invention is to provide an optical compensation sheet which improves viewing angle properties in a TN type LCD such as TN-TFT, that is, coloration or

image reversal phenomenon in a displayed image, when viewing the display obliquely.

Another object of the invention is to provide a liquid crystal display employing the optical compensation sheet, which has a simple structure and improves viewing angle properties.

BRIEF EXPLANATION OF THE DRAWINGS

Fig. 1 shows one embodiment of the optical compensation of the invention.

Fig. 2 shows one embodiment of the optical compensation of the invention.

Fig. 3 shows one embodiment of the optical compensation of the invention.

Fig. 4 shows a method of obtaining an average tilt angle from the relationship between retardation in the plane and an angle.

Fig. 5(a) shows the front view of optical compensation sheet 1 adhered to a liquid crystal cell (not illustrated).

Fig. 5(b) shows the sectional view of optical compensation sheet 1.

Fig. 6(a) shows the front view of optical compensation sheet 2 adhered to a liquid crystal cell (not illustrated).

Fig. 6(b) shows the sectional view of optical compensation sheet 2.

Fig. 7(a) shows the front view of optical compensation sheet 3 adhered to a liquid crystal cell (not illustrated).

Fig. 7(b) shows the sectional view of optical compensation sheet 3.

Fig. 8 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 9 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 10 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 11 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 12 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 13 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 14 shows one embodiment of preferable layer structures used in the liquid crystal display of the invention.

Fig. 15 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 16 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 17 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 18 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 19 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 20 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 21 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 22 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 23 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 24 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 25 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 26 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 27 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 28 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 29 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 30 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 31 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 32 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 33 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 34 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 35 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 36 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 37 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

Fig. 38 shows the sectional view of one embodiment of structures used in the liquid crystal display of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The above problems in the invention can be solved by the following constitutions:

1. An optical compensation sheet comprising at least two optically anisotropic layers each formed by orienting an optically anisotropic compound, the orientation direction in the optically anisotropic layer plane of the optically anisotropic compound in the two optically anisotropic layers intersecting each other at an angle of from 80 to 100 degrees,

wherein, viewing the two optically anisotropic layers from one side of the optical compensation sheet,

one of the two optically anisotropic layers, when the optically anisotropic compound is uniaxial, is oriented so that a first angle of the optic axis of the uniaxial optically anisotropic compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, or when the optically anisotropic compound is biaxial, is oriented so that a second angle of a direction giving

maximum refractive index of the biaxial optically anisotropic compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, and

the other optically anisotropic layer, when the optically anisotropic compound is uniaxial, is oriented so that the first angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, or when the optically anisotropic compound is biaxial, is oriented so that the second angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet.

2. The optical compensation sheet of claim 1, wherein the optically anisotropic compound is a liquid crystal compound.

3. The optical compensation sheet of claim 2, wherein the optically anisotropic compound is a positive uniaxial liquid crystal compound, the at least two optically anisotropic layers each are formed by orienting the positive uniaxial liquid crystal compound, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees, and wherein, viewing the two optically anisotropic

layers from one side of the optical compensation sheet, one of the two optically anisotropic layers is oriented so that the first angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other optically anisotropic layer is oriented so that the first angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet.

4. The optical compensation sheet of claim 2, wherein the optically anisotropic compound is a biaxial liquid crystal compound, the at least two optically anisotropic layers each are formed by orienting the biaxial liquid crystal compound, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees, and wherein, viewing the two optically anisotropic layers from one side of the optical compensation sheet, one of the two optically anisotropic layers is oriented so that the second angle of a direction giving maximum refractive index of the liquid crystal compound molecule to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and

the other optically anisotropic layer is oriented so that the second angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet.

5. The optical compensation sheet of claim 2, wherein the optically anisotropic compound is a negative uniaxial liquid crystal compound, the at least two optically anisotropic layers each are formed by orienting the negative uniaxial liquid crystal compound, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees, and wherein, viewing the two optically anisotropic layers from one side of the optical compensation sheet, one of the two optically anisotropic layers is oriented so that the first angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other optically anisotropic layer is oriented so that the first angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet.

6. The optical compensation sheet of claim 2, wherein the at least two optically anisotropic layers comprises a first optically anisotropic layer formed by orienting a

positive uniaxial liquid crystal compound and a second optically anisotropic layer formed by orienting a biaxial liquid crystal compound, and the orientation direction in the optically anisotropic layer plane of the two liquid crystal compounds in the first and second optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees, and wherein, viewing the two optically anisotropic layers from one side of the optical compensation sheet, the first optically anisotropic layer is oriented so that the first angle of the optic axis of the positive uniaxial liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, and the second optically anisotropic layer is oriented so that the second angle of a direction giving maximum refractive index of the biaxial liquid crystal compound molecule to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet.

7. The optical compensation sheet of claim 1, providing a wavelength dispersion property satisfying the following formulae (2) and (3):

formula (1)

$R_e = (nx1 - ny1) \times d$

formula (2)

R_e (589.3) − R_e (480) ≤ 45 nm

formula (3)

0.7 ≤ R_e (480)/R_e (589.3) ≤ 1.4

wherein, regarding the direction giving maximum refractive index in the plane of the optical compensation sheet as the X axis, the direction in the optical compensation sheet plane normal to the X axis as the Y axis, and the direction perpendicular to the optical compensation sheet plane as the Z axis, viewing the point (referred to also as the origin), at which the X, Y and Z axes intersect, from any point on the YZ plane perpendicular to the optical compensation sheet plane, and obtaining angle (θ) giving minimum of a retardation in the plane (Re) at wavelength 590 nm represented by formula (1) above in the plane perpendicular to the viewing direction, retardation Re (589.3) in the plane perpendicular to the viewing direction at the wavelength 589.3 nm and retardation Re (480) in the plane perpendicular to the viewing direction at the wavelength 480 nm each are measured at angle (θ), and

wherein nx1 represents maximum refractive index at wavelength 590 nm in the plane perpendicular to the viewing direction, ny1 represents minimum refractive index at

wavelength 590 nm in the plane perpendicular to the viewing direction, and d represents a thickness of the sheet.

8. The optical compensation sheet of claim 1, comprising at least one support.

9. The optical compensation sheet of claim 8, wherein one layer of the two optically anisotropic layers is provided on one side of the support and the other layer of the two optically anisotropic layers is provided on the other side of the support.

10. The optical compensation sheet of claim 8, wherein the two optically anisotropic layers are provided on one side of the support.

11. The optical compensation sheet of claim 8, comprising two supports, wherein the two optically anisotropic layers are provided between the two supports.

12. The optical compensation sheet of claim 8, wherein the support is transparent and substantially optically isotropic.

13. The optical compensation sheet of claim 8, wherein the support is transparent and has a negative uniaxial optical property with the optic axis in the direction perpendicular to the optical compensation sheet plane.

14. The optical compensation sheet of claim 13, wherein the support satisfies the following formulae (4) and (4'):

formula (4)

$nx2 \geq ny2 > nz2$

formula (4′)

$(nx2 - ny2)/nx2 \leq 0.01$

wherein nx2 represents maximum refractive index in the plane of the support, ny2 represents refractive index in the plane of the support in the direction perpendicular to the direction giving nx2, and nz2 represents refractive index in the support thickness direction.

15. The optical compensation sheet of claim 14, wherein the support has a retardation (R_t) in the thickness direction of 5 to 250 nm.

16. The optical compensation sheet of claim 8, wherein the support is comprised mainly of cellulose esters.

17. The optical compensation sheet of claim 1, wherein at least one of the two optically anisotropic layers has a retardation (R_0) in the plane of 50 to 200 nm, R_0 being represented by formula (a):

formula (a)

$R_0 = (nx - ny) \times d$

wherein nx represents maximum refractive index in the plane of the optically anisotropic layer, ny represents refractive index in the plane of the optically anisotropic layer in the direction perpendicular to the direction giving

nx, and d represents a thickness of the optically anisotropic layer.

18. The optical compensation sheet of claim 1, wherein at least one of the two optically anisotropic layers satisfies the following:

when the direction normal to the optically anisotropic layer is regarded as 90 degrees, the direction parallel to the optically anisotropic layer and giving maximum refractive index in the plane of the optically anisotropic layer is regarded as zero degrees, and retardation is measured at an incident angle of from 0 to 90 degrees to the optically anisotropic layer, angle θa (°), giving maximum retardation (R_e) in the plane at 590 nm represented by the following formula (1) in the plane perpendicular to the incident direction, is in the range of from more than zero degrees to less than 90 degrees, and the maximum value of retardation is in the range of from 65 to 250 nm,

formula (1)

$$R_e = (nx1 - ny1) \times d$$

wherein nx1 represents maximum refractive index at 590 nm in the plane perpendicular to the incident direction, ny1 represents minimum refractive index at 590 nm in the plane perpendicular to the incident direction, and d represents a thickness of the optical compensation sheet.

19. A liquid crystal display comprising a liquid crystal cell provided between a first polarizing plate and a second polarizing plate,

wherein an optical compensation sheet is provided either between the first polarizing plate and the liquid crystal cell or between the second polarizing plate and the liquid crystal cell, the optical compensation sheet comprising at least two optically anisotropic layers each formed by orienting an optically anisotropic compound, and the orientation direction in the optically anisotropic layer plane of the optically anisotropic compound in the two optically anisotropic layers intersecting each other at an angle of from 80 to 100 degrees, and

wherein, viewing the two optically anisotropic layers from one side of the optical compensation sheet,

one of the two optically anisotropic layers, when the optically anisotropic compound is uniaxial, is oriented so that a first angle of the optic axis of the uniaxial optically anisotropic compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, or when the optically anisotropic compound is biaxial, is oriented so that a second angle of a direction giving maximum refractive index of the biaxial optically

anisotropic compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, and

the other optically anisotropic layer, when the optically anisotropic compound is uniaxial, is oriented so that the first angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, or when the optically anisotropic compound is biaxial, is oriented so that the second angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet.

20. The liquid crystal display of claim 19, wherein the orientation direction of one of the two optically anisotropic layers is substantially perpendicular to the transmission axis of the first polarizing plate and is substantially parallel to the transmission axis of the second polarizing plate, or the orientation direction of one of the two optically anisotropic layers is substantially perpendicular to the transmission axis of the second polarizing plate and is substantially parallel to the transmission axis of the first polarizing plate.

21. A polarizing plate for elliptically polarized light comprising the optical compensation sheet.

22. An optical compensation sheet comprising at least two optically anisotropic layers each formed by orienting an optically positive uniaxial liquid crystal compound, wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is a layer which is oriented so that an angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other a layer which is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the plane of the two liquid crystal compounds in the two layers intersects each other at an angle of from 80 to 100 degrees.

23. The optical compensation sheet of item 22, wherein the at least two optically anisotropic layers are provided only on one side of a liquid crystal cell.

24. An optical compensation sheet comprising at least two optically anisotropic layers, each formed by orienting an optically biaxial liquid crystal compound, wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is a layer which is oriented so that an angle of the direction giving maximum

refractive index of the liquid crystal molecule to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other a layer which is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the plane of the liquid crystal compound in the two layers intersects each other at an angle of from 80 to 100 degrees.

25. The optical compensation sheet of item 24, wherein the at least two optically anisotropic layers are provided only on one side of a liquid crystal cell.

26. An optical compensation sheet comprising at least two optically anisotropic layers, each formed by orienting an optically negative uniaxial liquid crystal compound, wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is a layer which is oriented so that an angle of the optic axis of the liquid crystal molecule to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other a layer which is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in

the plane of the liquid crystal compound in the two layers intersects each other at an angle of from 80 to 100 degrees.

27. The optical compensation sheet of item 26, wherein the at least two optically anisotropic layers are provided only on one side of a liquid crystal cell.

28. An optical compensation sheet comprising at least two optically anisotropic layers, each formed by orienting a liquid crystal compound, wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is a layer in which the liquid crystal compound is an optically positive uniaxial liquid crystal compound, and an angle of the optic axis of the optically positive uniaxial liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other a layer in which the liquid crystal compound is an optically biaxial liquid crystal compound, and an angle of the direction giving maximum refractive index of the optically biaxial liquid crystal compound to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the plane of the liquid crystal compound in the two layers intersects each other at an angle of from 80 to 100 degrees.

29. The optical compensation sheet of item 28, wherein the at least two optically anisotropic layers are provided only on one side of a liquid crystal cell.

30. An optical compensation sheet comprising at least two optically anisotropic layers, each formed by orienting a liquid crystal compound, wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is a layer in which the liquid crystal compound is an optically positive uniaxial liquid crystal compound A, and angle A of the optic axis of the optically positive uniaxial liquid crystal compound to the optical compensation sheet plane decreases or increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other a layer in which the liquid crystal compound is an optically biaxial liquid crystal compound B, and angle B of the direction giving maximum refractive index of the optically biaxial liquid crystal compound to the optical compensation sheet plane increases or decreases continuously or stepwise in the thickness direction of the optical compensation sheet, provided that angles A and B viewing from the one side do not simultaneously increase nor decrease, and the orientation direction in the plane of the liquid crystal compounds A and

B in the two layers intersects each other at an angle of from 80 to 100 degrees.

31. The optical compensation sheet of item 30, wherein the at least two optically anisotropic layers are provided only on one side of a liquid crystal cell.

32. An optical compensation sheet comprising at least two optically anisotropic layers, each comprised of a birefringent material, wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is a layer which is oriented so that an angle of the direction giving maximum refractive index in the refractive index ellipsoid of the birefringent material to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other a layer which is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the plane of the birefringent materials in the two layers intersects each other at an angle of from 80 to 100 degrees.

33. The optical compensation sheet of item 32, wherein the at least two optically anisotropic layers are provided only on one side of a liquid crystal cell.

34. An optical compensation sheet comprising at least two optically anisotropic layers, each formed by orienting a liquid crystal compound, and the two optically anisotropic layers being provided only on one side of a liquid crystal cell,

(1) wherein, when viewing the two layers from one side of the optical compensation sheet, one of the layers is oriented so that an angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet, the other layer is oriented so that the angle increases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the plane of the liquid crystal compound in the two layers intersects each other at an angle of from 80 to 100 degrees, and

(2) wherein, when regarding the direction giving maximum refractive index in the plane of the optical compensation sheet as the X axis, the direction in the optical compensation sheet plane normal to the X axis as the Y axis, and the direction perpendicular to the optical compensation sheet plane as the Z axis, viewing the point (referred to also as the origin), at which the X, Y and Z axes intersect,

from any point on the YZ plane perpendicular to the optical compensation sheet plane, and obtaining angle (θ) giving minimum of a retardation (Re) in the plane represented by formula (1) in the plane perpendicular to the viewing direction, the optical compensation sheet has such a wavelength dispersion property that the retardation Re (589.3) in the plane at the wavelength 589.3 nm and the retardation Re (480) in the plane at the wavelength 480 nm, each being measured at angle (θ) obtained above, satisfy the following formulae (2) and (3):

formula (1)

$R_e = (nx1 - ny1) \times d$

formula (2)

$R_e\ (589.3) - R_e\ (480) \leq 45$ nm

formula (3)

$0.7 \leq R_e\ (480)/R_e\ (589.3) \leq 1.4$

wherein nx1 represents maximum refractive index at wavelength 589.3 nm in the plane (which is not necessarily the sheet plane) perpendicular to the incident direction, ny1 represents minimum refractive index at wavelength 589.3 nm in the plane, and d represents a thickness, and when there are plural layers as elements showing nx1 and nx2, d represents a thickness of the sheet.

35. An optical compensation sheet of any one of items 22 to 34, comprising two oriented layers, which are subjected to orientation treatment so that the orientation directions of the two oriented layers cross each other at an angle of from 80 to 100 degrees, a first optically anisotropic layer containing a liquid crystal compound to be oriented and fixed on the one oriented layer, and a second optically anisotropic layer containing a birefringent material to be oriented and fixed on the other oriented layer, wherein the first optically anisotropic layer is provided on one side of a support and the second optically anisotropic layer provided on the other side of the support.

36. An optical compensation sheet of any one of items 22 to 34, comprising two oriented layers, which are subjected to orientation treatment so that the orientation directions of the two oriented layers cross each other at an angle of from 80 to 100 degrees, a first optically anisotropic layer containing a liquid crystal compound to be oriented and fixed on the one oriented layer, and a second optically anisotropic layer containing a birefringent material to be oriented and fixed on the other oriented layer, wherein the first and second optically anisotropic layers are provided on one side of a support.

37. An optical compensation sheet of any one of items 22 to 34, comprising two oriented layers, which are subjected to orientation treatment so that the orientation directions of the two oriented layers cross each other at an angle of from 80 to 100 degrees, a first optically anisotropic layer containing a liquid crystal compound to be oriented and fixed on the one oriented layer, and a second optically anisotropic layer containing a birefringent material to be oriented and fixed on the other oriented layer, wherein the first and second optically anisotropic layers are provided between two supports.

38. An optical compensation sheet of item 35, wherein the two oriented layers, which orient an optically anisotropic layer, each is oriented layer A giving a pretilt angle of not more than 40 degrees or oriented layer B giving a pretilt angle of not less than 45 degrees.

39. An optical compensation sheet of any one of items 22 to 31, items 36 and 37, comprising a first optically anisotropic layer containing a liquid crystal compound A to be oriented and fixed provided on a first oriented layer A giving a pretilt angle of not more than 40 degrees and a second optically anisotropic layer containing a liquid crystal compound B to be oriented and fixed provided on a second oriented layer B giving a pretilt angle of not less

than 45 degrees, each being provided only on one side of a support, wherein the orientation directions in the plane of the first and second optically anisotropic layers intersect each other at an angle of from 80 to 100 degrees.

40. An optical compensation sheet of any one of items 22 through 34, items 35 and 37, wherein the sheet is manufactured by the method comprising the following steps (1), (2) and (3):

(1) forming a first optically anisotropic layer which is fixed at a temperature developing a liquid crystal phase of liquid crystal compound A, through oriented layer A subjected to orientation treatment, on a first support,

(2) forming a second optically anisotropic layer which is fixed at a temperature developing a liquid crystal phase of liquid crystal compound B, through oriented layer B subjected to orientation treatment, on a second support,

(3) laminating the first optically anisotropic layer onto the second optically anisotropic layer directly or through at least one layer selected from a sticky layer, an adhesive layer and other layers so that the orientation direction in the optical compensation sheet plane of the first and second optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees.

41. An optical compensation sheet of any one of items 22 through 34, and item 36, wherein the sheet is manufactured by the method comprising the following steps (1), (2) (3), and (4):

(1) forming a first optically anisotropic layer which is fixed at a temperature developing a liquid crystal phase of liquid crystal compound A, through oriented layer A subjected to orientation treatment, on a first support,

(2) forming a second optically anisotropic layer which is fixed at a temperature developing a liquid crystal phase of liquid crystal compound B, through oriented layer B subjected to orientation treatment, on a second support,

(3) laminating the second optically anisotropic layer on the first optically anisotropic layer directly or through at least one layer selected from a sticky layer, an adhesive layer and other layers so that the orientation direction in the optical compensation sheet plane of the first and second optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees, and

(4) peeling the second support.

42. A method for manufacturing an optical compensation sheet comprising continuous coating on a web support and comprising the following steps (1), (2) (3), and (4):

(1) continuously providing an orientation layer directly or through another layer on one side of a web support,
(2) orienting the orientation layer in the direction of approximately 45 degrees to the mechanical direction,
(3) continuously coating a crystal liquid compound on the resulting oriented layer and fixing at a temperature developing the crystal liquid phase to obtain a web sheet, and
(4) folding the web sheet into two along a line parallel to the mechanical direction on the surface of the web support, and laminating the folded two halves directly or through a sticky layer or other layers.

43. An optical compensation sheet of any one of items 22 through 34, and items 35 and 37, wherein the optical compensation sheet is manufactured by the method of item 21 above.

44. A method for manufacturing an optical compensation sheet comprising continuous coating on a web support and comprising the following steps (1), (2) (3), and (4):
(1) continuously providing an orientation layer directly or through another layer on one side of a web support,
(2) orienting the orientation layer in the direction of approximately 45 degrees to the mechanical direction,

(3) continuously coating a liquid crystal compound on the resulting oriented layer and fixing at a temperature developing the crystal liquid phase to obtain a web sheet, and

(4) laminating the two web sheets directly or through an adhesive layer or other layers so that the liquid crystal compound layers face each other or so that the supports face each other.

45. An optical compensation sheet of any one of items 22 through 34, and items 35 and 37, wherein the sheet is manufactured by the method of item 23 above.

46. A manufacturing method of the optical compensation sheet of item 42 or 44, the method comprising the steps of laminating the two web sheets with the supports facing outwardly, and peeling one of the supports.

47. An optical compensation sheet of any one of items 22 through 41, and items 43 and 45, wherein the support is transparent and substantially optically isotropic.

48. An optical compensation sheet of any one of items 22 through 41, and items 43 and 45, wherein the support is transparent and has a negative uniaxial optical property having the optic axis in the direction perpendicular to the optical compensation sheet plane.

49. An optical compensation sheet of item 48, wherein the support satisfies the following formula (4):

formula (4)

$nx2 \geq ny2 > nz2$

wherein nx2 represents maximum refractive index in the plane of the support, ny2 represents refractive index in the plane of the support in the direction perpendicular to the direction giving nx2, and nz2 represents refractive index in the thickness direction of the support, provided that the difference between nx2 and ny2 is not more than 1%.

50. An optical compensation sheet of item 49, wherein the support has a retardation (R_t) in the thickness direction of 5 to 250 nm.

51. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47, 48 and 49, wherein the support is transparent, and is comprised mainly of cellulose esters.

52. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47, 48, 49 and 51, wherein the optical compensation sheet is provided between a polarizing plate and a liquid crystal cell of a liquid crystal panel for driving, the orientation direction in the plane of one optically anisotropic layer is approximately perpendicular to the transmission axis of the polarizing plate, and the

orientation direction in the plane of the other optically anisotropic layer is approximately parallel to the transmission axis of the polarizing plate.

53. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 50 and 51, wherein at least one of the at least two optically anisotropic layers has a retardation (R_0) in the plane of 50 to 200 nm, retardation (R_0) in the plane being represented by the following formula (a):

formula (a)

$R_0 = (nx - ny) \times d$

wherein nx represents maximum refractive index in the plane in the X direction, ny represents refractive index in the plane in the direction perpendicular to the direction giving nx, and d represents a thickness (nm) of the support.

54. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 51 and 52, wherein at least one of the two optically anisotropic layers satisfies the following:

when regarding the normal direction as 90 degrees, and the direction parallel to the optically anisotropic layer and giving maximum refractive index in the plane of the optically anisotropic layer as zero degrees, angle θa (°), giving a maximum of a retardation (R_e) in the plane

represented by formula (1) above, is within the range of from more than zero degrees to less than 90 degrees, and the retardation maximum is within the range of from 65 to 250 nm, the retardation being measured at an incident angle of from 0 to 90 degrees to the optically anisotropic layer.

55. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 53 and 54, wherein the angle giving a maximum of a retardation (R_e) in at least one of the two optically anisotropic layers is in the range of from 20 degrees to 70 degrees, the angle being represented by an angle between the direction normal to the optical compensation sheet plane and the orientation direction of the optically anisotropic layer.

56. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 54 and 55, wherein the direction giving a minimum of a retardation (R_e) in the plane represented by formula (1) above is in the range of from 10 to 75 degrees.

57. An optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 55 and 56, wherein at least one of the two optically anisotropic layers has a thickness of 0.5 to 2.2 μm.

58. A liquid crystal display, comprising a liquid crystal cell, in which a nematic type liquid crystal

compound is incorporated between two substrates, the orientation directions of which intersect approximately 90 degrees, the liquid crystal cell being provided between two polarizing elements, and the optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 56 and 57 (the sheet may be integrated with the polarizing element) being provided between the liquid crystal cell and one of the two polarizing elements, wherein when viewing the two optically anisotropic layers from the substrate side with respect to the direction normal to the substrate, one of the layers is a layer in which an angle between the direction giving maximum refractive index in the refractive index ellipsoid and the substrate increases continuously or stepwise in the direction farther from the substrate, and the other a layer in which the angle decreases continuously or stepwise in the direction farther from the substrate, the two orientation directions each giving maximum refractive index in the plane of the two optically anisotropic layers intersect approximately 90 degrees, and the orientation direction giving maximum refractive index in the plane of the optically anisotropic layer is approximately parallel with the orientation direction of the substrate.

59. A liquid crystal display comprising the optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 56 and 57.

60. A liquid crystal display comprising the optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 56 and 57, wherein the sheet is provided between a liquid crystal cell and a polarizing plate (referred to also as a polarizing element), the sheet being provided either on the display side or on the back light side of the liquid crystal cell.

61. A liquid crystal display comprising, in the display panel, the optical compensation sheet of any one of items 22 through 41, and items 43, 45, 47 to 56 and 57 between a polarizing plate (or polarizing element) and a liquid crystal cell for driving, the optical compensation sheet comprising an optically anisotropic layer, wherein when viewing the anisotropic layer from the upper or lower end side of the display panel, the projected optical alignment in the sheet thickness direction is symmetrical with respect to a center line in the sheet thickness direction at the sheet center from the obverse side to the rear side of the sheet.

62. An optical compensation sheet, with which a liquid crystal display is provided, comprising at least two

optically anisotropic layers formed by orienting a liquid crystal compound, wherein

(1) the optical compensation sheet is provided between a liquid crystal cell and a polarizing element, the optical compensation sheet being integrated with a polarizing plate including the polarizing element, and

(2) the surface side of the polarizing plate provided on the optical compensation sheet opposite the optical compensation sheet side is subjected to anti-reflection treatment, anti-glare treatment or hard coat treatment.

63. An optical compensation sheet, with which a liquid crystal display is provided, comprising at least two optically anisotropic layers formed by orienting a liquid crystal compound, wherein

(1) the optical compensation sheet is provided between a liquid crystal cell and a polarizing element, the optical compensation sheet being integrated with a polarizing plate including the polarizing element, and

(2) when viewing the two layers from one side of the optical compensation sheet, one of the two layers is a layer which is oriented so that an angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane decreases continuously or stepwise in the direction of the optical compensation sheet thickness direction, and the

orientation direction in the plane of the liquid crystal compound in the two layers intersect each other at an angle of from 80 to 100 degrees, and

(3) the surface side of the polarizing plate provided on the optical compensation sheet is subjected to anti-reflection treatment, anti-glare treatment or hard coat treatment.

64. An optical compensation sheet, with which a liquid crystal display is provided, comprising at least two optically anisotropic layers each formed by orienting a liquid crystal compound, wherein

(1) the optical compensation sheet is provided between a liquid crystal cell and a polarizing element, the optical compensation sheet being integrated with a polarizing plate including the polarizing element,

(2) when viewing the two layers from one side of the optical compensation sheet, one of the two layers is a layer which is oriented so that an angle of the major axis of the liquid crystal compound to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet and the orientation direction in the plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees,

(3) the surface side of the polarizing plate provided on the optical compensation sheet is subjected to anti-reflection treatment, anti-glare treatment or hard coat treatment, and (4) when regarding the direction giving maximum refractive index in the plane of the optical compensation sheet as X axis, the direction in the optical compensation sheet plane normal to the X axis as the Y axis, and the direction perpendicular to the optical compensation sheet plane as the Z axis, viewing the point (referred to also as the origin), at which the X, Y and Z axes intersect, from any point on the YZ plane perpendicular to the optical compensation sheet plane, and obtaining an angle (θ) giving minimum of a retardation (Re) in the plane represented by formula (1) in the plane perpendicular to the viewing direction, the optical compensation sheet has such a wavelength dispersion property that the retardation Re (589.3) in the plane at the wavelength 589.3 nm and the retardation Re (480) in the plane at the wavelength 480 nm, each being measured at the angle (θ), satisfy formulae (2) and (3) above.

65. An optical compensation sheet, with which a liquid crystal display is provided, comprising at least two optically anisotropic layers each formed by orienting a liquid crystal compound, wherein

(1) the optical compensation sheet is provided between a liquid crystal cell and a polarizing element, the optical compensation sheet being integrated with a polarizing plate including the polarizing element,

(2) when viewing the two layers from one side of the optical compensation sheet, one of the two layers is a layer which is oriented so that an angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet and the orientation direction in the plane of the optically anisotropic compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees, and

(3) the surface side of the polarizing plate provided on the optical compensation sheet is subjected to anti-reflection treatment, anti-glare treatment or hard coat treatment.

66. An optical compensation sheet, with which a liquid crystal display is provided, comprising at least two optically anisotropic layers each formed by orienting a liquid crystal compound, wherein

(1) the optical compensation sheet is provided between a liquid crystal cell and a polarizing element, the optical

compensation sheet being integrated with a polarizing plate including the polarizing element,

(2) when viewing the two layers from one side of the optical compensation sheet, one of the two layers is a layer which is oriented so that an angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet and the orientation direction in the plane of the optically anisotropic compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees,

(3) the surface side of the polarizing plate provided on the optical compensation sheet is subjected to anti-reflection treatment, anti-glare treatment or hard coat treatment, and

(4) when regarding the direction giving maximum refractive index in the plane of the optical compensation sheet as X axis, the direction in the optical compensation sheet plane normal to the X axis as the Y axis, and the direction perpendicular to the optical compensation sheet plane as the Z axis, viewing the point (referred to also as the origin), at which the X, Y and Z axes intersect, from any point on the YZ plane perpendicular to the optical compensation sheet plane, and obtaining an angle (θ) giving minimum of a retardation (Re) in the plane represented by formula (1) in

the plane perpendicular to the viewing direction, the optical compensation sheet has such a wavelength dispersion property that the retardation Re (589.3) in the plane at the wavelength 589.3 nm and the retardation Re (480) in the plane at the wavelength 480 nm, each being measured at the angle (θ), satisfy formulae (2) and (3) above.

67. A liquid crystal display comprising the optical compensation sheet of any one of items 62 to 66.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Next, the present invention will be explained in detail.

The optical compensation sheet of the invention comprises at least two optically anisotropic layers each formed by orienting an optically anisotropic compound. Viewing the two layers from one side of the optical compensation sheet, one of the two layers, when the optically anisotropic compound is uniaxial, is oriented so that a first angle of the optic axis of the uniaxial optically anisotropic compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet and the other is oriented so that the first angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, or when the optically

anisotropic compound is biaxial, is oriented so that a second angle of a direction giving maximum refractive index of the biaxial optically anisotropic compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, and the other layer, when the optically anisotropic compound is uniaxial, is oriented so that the first angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, or when the optically anisotropic compound is biaxial, is oriented so that the second angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, wherein the orientation direction in the optically anisotropic layer plane of the optically anisotropic compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees.

In the invention, the orientation direction in the optically anisotropic layer plane of the optically anisotropic compound in the two optically anisotropic layers intersects each other at an angle of preferably from 85 to 95 degrees, and more preferably 90 degrees. In the invention, the optically anisotropic layers formed by orienting an optically anisotropic compound is preferably

optically anisotropic layers formed by orienting the optically anisotropic compound and fixing it.

In the invention, the optical compensation sheet preferably means a sheet overcoming birefringence of a liquid crystal cell in a liquid crystal display between the liquid crystal cell and a polarizing plate. Examples of the optical compensation sheet include a viewing angle increasing film. The viewing angle increasing films include a film capable of increasing viewing angle and maintaining good contrast, a film capable of increasing viewing angle and overcoming reversal of gray scale, a film capable of increasing viewing angle and maintaining good black image, a film capable of increasing viewing angle and maintaining good hue, and a film with these plural effects capable of increasing viewing angle.

The optically anisotropic compound in the invention means a compound in which at least one of refractive indices nx, ny, and nz in the three axis X, Y, and Z directions is different from the other refractive indices. When the aggregates comprising a plurality of molecules show the above property, the optically anisotropic compounds in the invention mean such aggregates.

Conventional optical compensation sheets show an optical compensation property capable of being put into practical

use only by providing it on both sides of a liquid crystal cell. Surprisingly, the present inventors have found that an extremely excellent optical compensation property has been obtained by providing only one optical compensation sheet comprising the optically anisotropic layer as described and structured above between a liquid crystal cell and a polarizing plate sheet, the optical compensation sheet being provided on one side of the liquid crystal cell or the polarizing plate sheet.

The optical compensation sheet of the invention provides such excellent optical compensation properties that it shows high contrast with a so-called, wide viewing angle, no coloring on the sheet plane, and a very narrow reversal area, when viewing the optical compensation sheet from an oblique direction. The use of only one optical compensation sheet of the invention per liquid crystal cell reduces cost by half, and the optical compensation sheet of the invention can be applied to twice as many liquid crystal cells as the conventional optical compensation sheet.

A sheet in which optical compensation can be carried out by the use of only one optical compensation sheet has the following advantages due to positioning of the optical compensation sheet in providing it in a liquid crystal display panel.

Generally, a polarizing plate on the display side (observer side) is different in surface properties from the rear (back light) side of a liquid crystal cell. On the display side, for example, a special polarizing plate is used in which the surface of the polarizing plate is subjected to AG (anti-glare) treatment. In this case, for example, the obverse side of the polarizing plate is subjected to AG treatment, and an optical compensation film is adhered to the rear side of the polarizing plate, resulting in more manufacturing processes, which may lower yields. Once problems occur during adherence of the surface treated polarizing plate to an optical compensation film, there is nothing to be done but to discard the polarizing plate, also resulting in cost increase. However, the optical compensation sheet according to the invention can be laminated onto the surface of a polarizing plate on the back light side of a liquid crystal cell, which does not require special surface treatment, saving a polarizing plate having the additional property as described above. Further, the optical compensation sheet of the invention is advantageously laminated onto a polarizing plate on the obverse side the surface of which has been subjected to surface treatment such as AG treatment. That is, although two polarizing plates are essential to a liquid crystal

display, it is possible to use an ordinary polarizing plate without special surface treatment as one used on the rear side of the display. As a result, it is possible to use, in common, ordinary polarizing plates and other parts used in various liquid crystal displays, resulting in reduction of cost.

Yellowing, which results from triacetyl cellulose used in an optical compensation sheet, or for example, a wavelength dispersion property of a discotic liquid crystal compound etc., can be restrained by use of the optical compensation sheet of the invention, since the number of the optical compensation sheet used is reduced to one.

The present invention provides an optical compensation sheet capable of attaining optical compensation by only one sheet, a polarizing plate employing the same, and a liquid crystal display employing the same. Further, the present invention improves contrast variation due to viewing angle which is specific to a twisted nematic (TN) type liquid crystal display or particularly dependence of image quality upon viewing angle in an active matrix type liquid crystal display used as a full color display.

As a technique described above, there is the description in Japanese Patent O.P.I. Publication No. 10-186356, "an optical compensation sheet can also be provided only on one

side of a liquid crystal display." However, there are no examples in which reverse area, contrast or hue in a TN-TFT type liquid crystal display is improved by providing an optical compensation sheet on only one side of the display.

Preferred examples of the optically anisotropic compounds in the invention include a liquid crystal compound. For example, when the optically anisotropic compound is a positive uniaxial liquid crystal compound, at least two optically anisotropic layers are formed by orienting the positive uniaxial liquid crystal compound. When viewing the two layers from one side of the optical compensation sheet, it is preferred in the invention that one of the two layers is oriented so that the angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, the other layer is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees.

When the optically anisotropic compound is a biaxial liquid crystal compound, at least two optically anisotropic layers each are formed by orienting the biaxial liquid crystal compound. When viewing the two layers from one side of the optical compensation sheet, it is preferred in the invention that one of the two layers is oriented so that the angle of a direction giving maximum refractive index of the liquid crystal compound molecule to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, the other layer is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees.

When the optically anisotropic compound is a negative uniaxial liquid crystal compound, at least two optically anisotropic layers each are formed by orienting the negative uniaxial liquid crystal compound. When viewing the two layers from one side of the optical compensation sheet, it is preferred in the invention that one of the two layers is oriented so that the angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane

increases continuously or stepwise in the thickness direction of the optical compensation sheet, the other layer is oriented so that the angle decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees.

The liquid crystal compound used in one of the two optically anisotropic layers is different from one used in the other optically anisotropic layer. One example will be shown below which comprises an optically anisotropic layer formed by orienting a positive uniaxial liquid crystal compound and an optically anisotropic layer formed by orienting a biaxial liquid crystal compound. When viewing the two layers from one side of the optical compensation sheet, it is preferred in the invention that the optically anisotropic layer comprising an optically anisotropic layer formed by orienting a positive uniaxial liquid crystal compound is oriented so that the angle of the optic axis of the liquid crystal compound to the optical compensation sheet plane increases continuously or stepwise in the thickness direction of the optical compensation sheet, the optically anisotropic layer comprising an optically

anisotropic layer formed by orienting the biaxial liquid crystal compound is oriented so that the angle of a direction giving maximum refractive index of the liquid crystal compound molecule to the optical compensation sheet plane decreases continuously or stepwise in the thickness direction of the optical compensation sheet, and the orientation direction in the optically anisotropic layer plane of the liquid crystal compound in the two optically anisotropic layers intersects each other at an angle of from 80 to 100 degrees. Other examples of the optically anisotropic compounds may be ones obtained by cutting a single crystal compound in a specific angle and thickness.

The optical compensation sheet of the invention preferably provides a wavelength dispersion property satisfying the following formulae (2) and (3):

formula (1)

$R_e = (nx1 - ny1) \times d$

formula (2)

$R_e\ (589.3) - R_e\ (480) \leq 45$ nm

formula (3)

$0.7 \leq R_e\ (480)/R_e\ (589.3) \leq 1.4$

wherein, regarding the direction giving maximum refractive index in the plane of the optical compensation sheet as the X axis, the direction in the optical

compensation sheet plane normal to the X axis as the Y axis, and the direction perpendicular to the optical compensation sheet plane as the Z axis, viewing the point (referred to also as the origin), at which the X, Y and Z axes intersect, from any point on the YZ plane perpendicular to the optical compensation sheet plane, and obtaining angle (θ) giving minimum of a retardation (Re) at wavelength 590 nm in the plane represented by formula (1) above in the plane perpendicular to the viewing direction, retardation Re (589.3) in the plane at the wavelength 589.3 nm and retardation Re (480) in the plane at the wavelength 480 nm each are measured at angle (θ), and

wherein nx1 represents maximum refractive index at wavelength 590 nm in the plane perpendicular to the viewing direction, ny1 represents minimum refractive index at wavelength 590 nm in the plane perpendicular to the viewing direction, and d represents a thickness of the sheet.

Orientation of a liquid crystal compound in a liquid crystal compound layer in the invention will be explained below.

The wavelength dispersion property in the invention, when the incident direction is a normal direction, is represented by the subtraction of retardation in the plane at 480 nm from retardation in the plane at 589.3 nm and the

ratio of the retardation at 480 nm to the retardation at 589.3 nm, the retardation in the plane at 589.3 nm being regarded as standard. The wavelengths of 589.3 nm, 590 nm and 480 nm vary a little depending on the measuring device used, but the deviation within the range ±1 nm does not need correction. Further, the deviation within the range ±5 nm does not need correction also, but retardation at 480 or 589.3 nm is preferably obtained according to the method described later.

The wavelength dispersion property of the optical compensation sheet of the invention is influenced by a tilt angle of the liquid crystal molecules used in the sheet or lamination methods of optically anisotropic layers. The wavelength dispersion property of one optically anisotropic layer does not necessarily accord with the property of materials used in it, and the wavelength dispersion property due only to the materials cannot be applied to the wavelength dispersion property of the optical compensation sheet.

When the direction perpendicular to the sheet plane is defined as 0 degrees, and the axis giving maximum refractive index in the sheet plane is a rotational axis, the wavelength dispersion of the optical compensation sheet of the invention is computed from measurements measured

employing lights having wavelengths of 589.3 nm and 480 nm from the point, which gives a minimum of retardation (R_e) as represented by formula (1) above obtained of from measurements measured with the angle of incidence from -90 to 90 degrees along the axis giving minimum refractive index in the sheet plane.

When the measurement at 480 nm, 589.3 nm and 590 nm is difficult, retardation at 480 nm, 589.3 nm and 590 nm can be calculated by the following formula:

$$R(\lambda) = a + b/\lambda^2 + c/\lambda^4 + d/\lambda^6 + \ldots$$

wherein λ is a wavelength selected at intervals of from 50 to 100 nm in the wavelength range of from 450 to 800 nm, and $R(\lambda)$ is retardation at λ measured under the conditions described above. The more the data, the more preferable. Three data has substantially no problem, and four data are more preferable.

In view of obtaining the effects of the invention, in the wavelength dispersion property of the optical compensation sheet of the invention, R_e (589.3) - R_e (480) represented by formula (2) above is preferably not more than 45 nm, and more preferably not more than 15 nm, and the ratio R_e (480)/R_e (589.3) is preferably from 0.7 to 1.4, and more preferably from 0.8 to 1.2.

In the optical compensation sheet which is provided on only one side of the liquid crystal cell used in a liquid crystal display represented by a TN-TFT type liquid crystal display, the wavelength dispersion property adjusted to fall within the range as described above can provide improved contrast and improved properties (such as visual property or viewing angle property) at an image reverse area (particularly at lower portions) of the display, and can particularly minimize the problem in conventional optical compensation sheets such as yellowing occurring when viewing the display obliquely, and realize good color reproduction, resulting in an extremely high quality display.

It has been found in the present invention that yellowing of a displayed image of the liquid crystal display, which has so far been a great problem, has been reduced by adjusting the wavelength dispersion property of the optical compensation sheet, particularly the relationship between retardation (R_e) at 589.3 nm and retardation (R_e) at 480 nm, to a specific range. The present invention provides a liquid crystal display with good color reproduction by employing the optical compensation sheet of the invention minimizing the above problem. It is preferred that with respect to the relationship with a retardation R_e (λ') at visible wavelength λ' longer than 589.3 nm, value R_e

(589.3) - R_e (λ') is smaller than value $|R_e$ (589.3) - R_e (480)$|$, and value R_e (λ')/R_e (589.3) is in the range of from 0.7 to 1.3.

Besides the optically anisotropic layer, the optical compensation sheet may have a support, or an oriented layer for orienting an optically anisotropic compound in the optically anisotropic layer. Further, the optical compensation sheet may be integrated with a polarizing plate or a polarizing plate protective film. One optically anisotropic layer may be provided on one side of the support and the other optically anisotropic layer may be provided on the other side of the support. The two optically anisotropic layers may be provided on only one side of the support. The optical compensation sheet may comprise two supports, wherein the two optically anisotropic layers are provided between the two supports. An oriented layer may be provided between the support and the optically anisotropic layer or between two optically anisotropic layers. The oriented layer may give a pretilt angle of not more than 40 degrees or a pretilt angle of not less than 45 degrees. It is preferred that the support is transparent and substantially optically isotropic. The support may have a negative uniaxial optical property with the optic axis in the direction perpendicular to the optical compensation sheet plane. When the support

has a negative uniaxial optical property with the optic axis in the direction perpendicular to the optical compensation sheet plane, the support preferably satisfies the following formulae (4) and (4'):

formula (4)

$nx2 \geq ny2 > nz2$

formula (4')

$(nx2 - ny2)/nx2 \leq 0.01$

wherein nx2 represents maximum refractive index in the plane of the support, ny2 represents refractive index in the plane of the support in the direction perpendicular to the direction giving nx2, and nz2 represents refractive index in the support thickness direction.

When the support has a negative uniaxial optical property with the optic axis in the direction perpendicular to the optical compensation sheet plane, the support preferably has a retardation (R_t) in the thickness direction of 5 to 250 nm.

Materials used for the support will be detailed later, but the support comprises cellulose esters in an amount of preferably 50 weight % or more, and more preferably 80 weight % or more.

In the optical compensation sheet of the invention, it is preferred that at least one of the two optically

anisotropic layers (preferably the two optically anisotropic layers each) has a retardation (R_0) in the plane of 50 to 200 nm, R_0 being represented by formula (a):

formula (a)

$R_0 = (nx - ny) \times d$

wherein nx represents maximum refractive index in the plane of the optically anisotropic layer, ny represents refractive index in the plane of the optically anisotropic layer in the direction perpendicular to the direction giving nx, and d represents a thickness of the optically anisotropic layer.

In the optical compensation sheet of the invention, it is preferred that at least one of the two optically anisotropic layers (preferably two optically anisotropic layers each) satisfies the following conditions:

when the direction normal to the optically anisotropic layer is regarded as 90 degrees, the direction parallel to the optically anisotropic layer and giving a maximum refractive index in the plane of the optically anisotropic layer is regarded as zero degrees, and retardation is measured at an incident angle of from 0 to 90 degrees to the optically anisotropic layer, angle θa (°), giving maximum retardation (R_e) in the plane at 590 nm represented by the following formula (1) in the plane perpendicular to the

incident direction, is in the range of from more than zero degrees to less than 90 degrees, and the retardation maximum is in the range of from 65 to 250 nm,

formula (1)

$R_e = (nx1 - ny1) \times d$

wherein nx1 represents maximum refractive index at 590 nm in the plane perpendicular to the incident direction, ny1 represents minimum refractive index at 590 nm in the plane perpendicular to the incident direction, and d represents a thickness of the sheet.

In the above embodiment, θa is more preferably in the range of 20 to 70 degrees. Further, angle giving minimum of retardation (R_e) in the plane is more preferably in the range of from 10 to 75 degrees.

Thickness of the optically anisotropic layer is in the range of preferably 0.5 to 2.2 µm, and thickness of the optical compensation sheet of the invention is in the range of preferably 1 to 1,000 µm and more preferably 30 to 500 µm.

In the invention, there can be used an optical compensation sheet comprising two optically anisotropic layers having the same materials and the same layer thickness as the optical compensation sheet of the invention, in which one optically anisotropic layer is of

substantially the same orientation form as the other. Such an optical compensation sheet is obtained by turning one of the two optically anisotropic layers of the optical compensation sheet of the invention so that the orientation direction of the optically anisotropic compound in the two optically anisotropic layers is substantially the same.

The optical compensation sheet of the invention comprises two or more layers formed by orienting birefringent materials, characterized in that the orientation directions of the two layers are approximately normal in the plane to each other. The term "approximately normal" means that it may deviate a little from 90 degrees as far as there is no problem such as coloration due to interference, but means a range of preferably from 80 to 100 degrees, more preferably a range of from 85 to 95 degrees, and most preferably 90 degrees. Further, a component unit of the birefringent materials is oriented in one of the two layers so that the angle between the direction giving maximum refractive index in a refractive index ellipsoid of the component unit and the optical compensation sheet plane increases in the thickness direction of the sheet toward the other side (B) from one side (A) of the optical compensation sheet, and is oriented in the other layer so that the angle decreases in the thickness direction of the optical

compensation sheet toward the other side B from one side A of the optical compensation sheet.

The component unit of the birefringent materials herein referred to is considered to be a component having the optic axis. For example, the component unit means a liquid crystal molecule having a birefringent property. However, it is not necessarily limited to the molecule unit, and may be an aggregate having a specific optic axis, which is comprised of several kinds of molecules. The expression, "the angle described above to the sheet plane increases or decreases" means that each layer does not have the optic axis as the whole layer, and increase or decrease of the angle in the thickness direction of the sheet may be continuous or discontinuous. Hereinafter, this orientation in the thickness direction of the sheet refers to also as hybrid orientation. With respect to the hybrid orientation form effective for the present invention, the following can be mentioned. For example, in the sheet comprising two layers, it is preferred that the angle described above increases in the direction towards the side B from the side A in one layer, and decreases in the direction towards the side B from the side A in the other layer, or that the angle decreases in the direction towards the side B from the side A in one layer, and increases in the direction towards the

side B from the side A in the other layer. When the angles in the two layers increase or decrease simultaneously, or are constant, the effects of the invention cannot be obtained. The angle can vary in the range between 0 degrees and 90 degrees. The angle varies in the range of preferably 5 degrees to 85 degrees. The range is preferably wider, but varies due to the structure of the liquid crystal cell used. With respect to the varying form (hybrid form) of the angle, the varying form in one layer is preferably the same as that in the other layer in the section of the sheet.

In the optical compensation sheet of the invention, it is preferred that one of the two optically anisotropic layers has a retardation (R_0) in the plane represented by formula (a) of 50 to 200 nm. Further, it is more preferred that the two optically anisotropic layers each have a retardation (R_0) in the plane represented by formula (a) of preferably 50 to 200 nm.

In the optical compensation sheet of the invention, it is preferred that angle θa (°) giving maximum retardation (R_e) in the plane represented by formula (1) in the plane of at least one of the two optically anisotropic layers is in the range of from more than zero degrees to less than 90 degrees, and preferably from 20 to 70 degrees, and the retardation maximum of R_e is in the range of from 65 to 250